Experimental and computational investigations aimed at improving stability and controllability of a “flying wing” aircraft configuration

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Investigated is a possibility of improving the characteristics of directional stability and longitudinal and directional controllability of a “flying wing” aircraft configuration by virtue of twin tail unit with fins inclined to the plane of symmetry at angle of 50 degrees (figure 1).

The experiment was carried out in the TsAGI T-102 wind tunnel at the free stream velocity of 50 m/s in the of angle of attack range from -4 to 24 deg. and angle of sidesleep range from -16 to 16 deg.

The “flying wing” aircraft test model had an aspect ratio of 6.6. Model was manufactured without inlet devices, internal ducts and nozzles. Fulfilled on the model were elevons, outer split elevons and rudders on the tail unit (see figure 1).

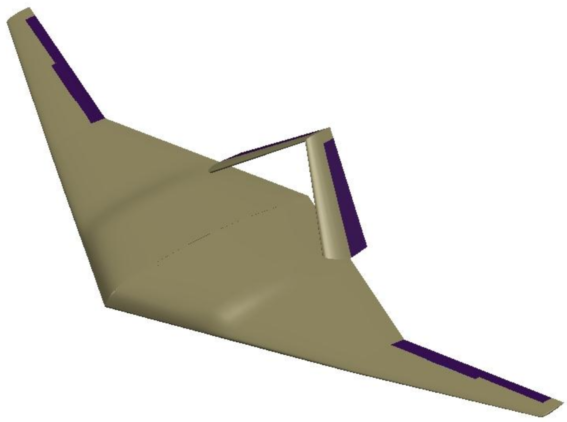


Figure 1 – CAD representation of the aircraft test model

Experiment showed that installation on the model of the tail unit resulted in some increase in the drag coefficient at zero lift, but provided for the model directional stability (figure 2)

In comparison with the split elevons the tail unit rudder is more effective in yaw control. Its

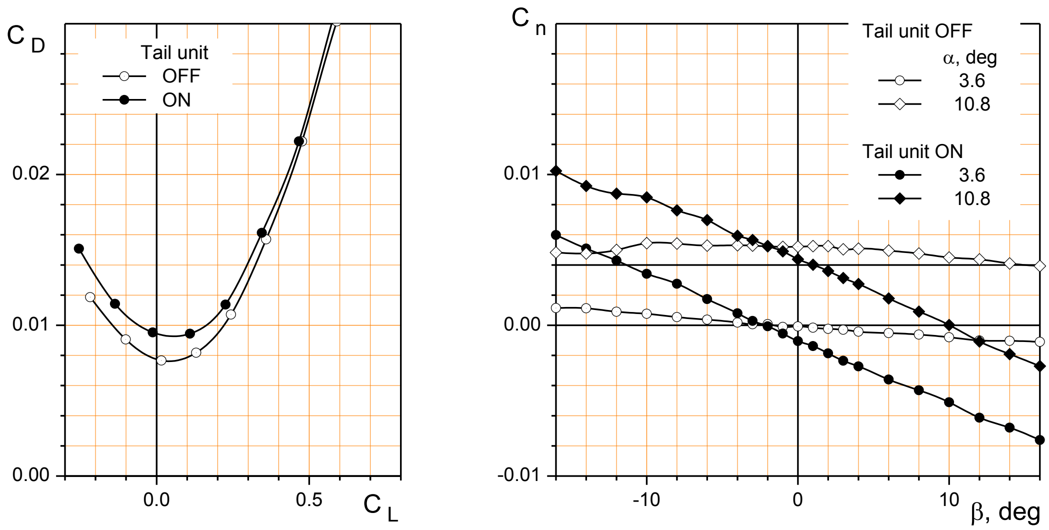
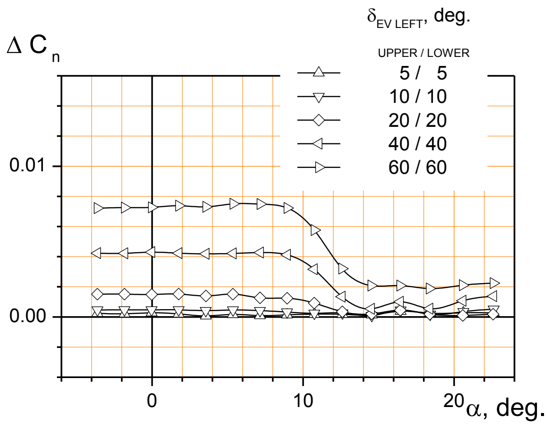


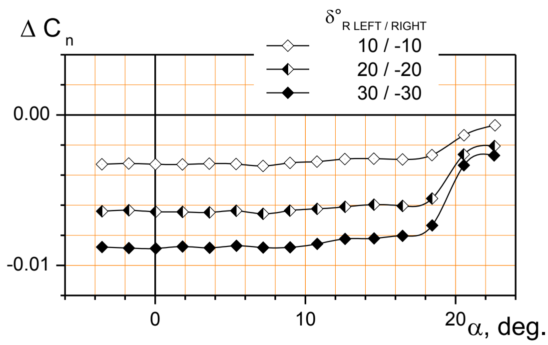
Figure 2 – The effect of tail unit installation on the drag polar and lateral static stability of the model

effectiveness remains practically intact in the angle of attack range from -4 to 18 deg., whereas the split elevon effectiveness abruptly decreases at angles of attack above 10 deg. Moreover, creating the control yawing moment by virtue of tail unit rudder deflection is accompanied by several times smaller increments in the drag coefficient than in the elevon splitting (figure 3).

It is also shown that tail rudder is an effective longitudinal control as well: in comparison with elevons it has nearly twice longer arm and its effectiveness is practically constant in the angle of attack range from -4 to 18 deg, whereas elevon effectiveness diminishes starting from angle of attack of about 10 deg (figure 4).

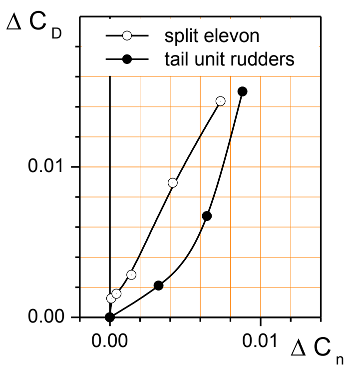


The yawing moment coefficient increment due to splitting the elevon on the left wing panel



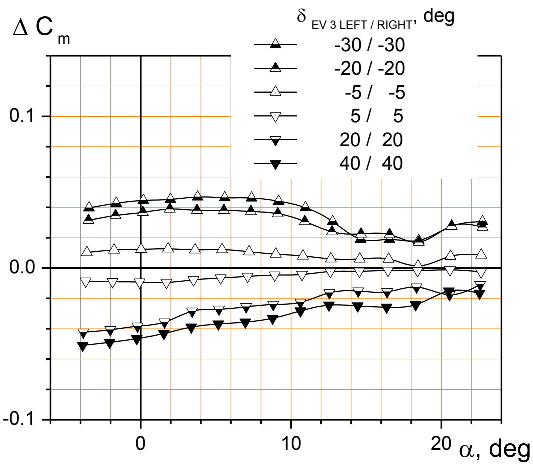
The yawing moment coefficient increment due to antisimmentrical deflection of the tail unit rudders

Angle of attack α = 4 deg.

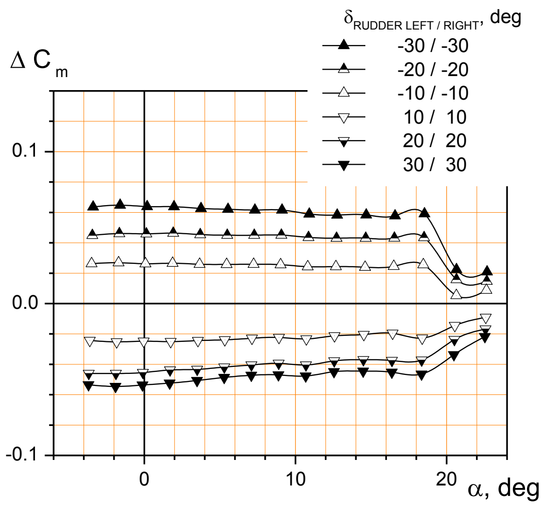


The drag coefficient increment of the model due to control surface deflection as function of the yawing moment increment

Figure 3 – Comparison of the effectiveness of the split elevon and the tail unit rudder in yaw control



Increments of the pitching moment coefficient due to deflection of the section 3 of the elevon



Increments of the pitching moment coefficient due to deflection of the tail rudder

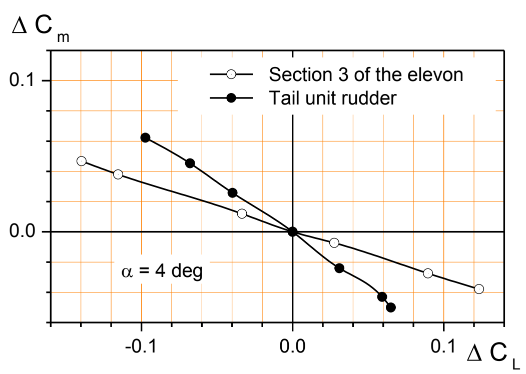


Figure 4 – Comparison of the longitudinal effectiveness of the section 3 of the elevon and the tail rudder

Numerical investigation of the configuration (RANS, ANSYS CFX with SST turbulence model) showed that local static longitudinal instability of the model, obtained in the wind tunnel experiment at angles of attack above 10 degrees, may not appear in full scale conditions up to angles of attack of 16 degrees (figure 5).

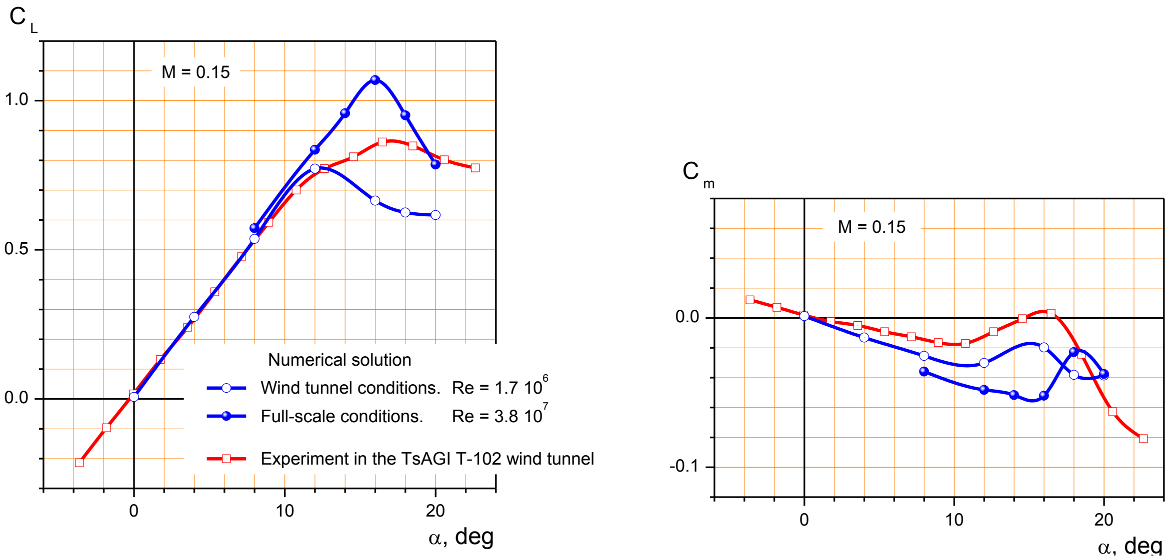


Figure 5 – The results of numerical investigation of the Reynolds number effect on the lift and the pitching moment coefficients of the “flying wing” configuration aircraft